Diptera Associated with Cones and Seeds of North American Conifers: An Annotated Bibliography

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FOREWORD

This annotated bibliography contains 108 references from North American literature on Diptera associated with cones and seeds of conifers. These references address some aspect of biology, ecology, taxonomy, or control of the North American species. Several publications are general in nature or include other insects; for these, the annotations were confined to the subject.

Two abstracting journals, Forestry Abstracts and Review of Applied Entomology, were primarily used in compiling this bibliography. References were also obtained from: *Barcia, D.R. and E.D. Merkel. 1972. Bibliography on insects destructive to flowers, cones, and seeds of North American conifers. USDA For. Serv. Res. Pap. SE-92, 80 pp.* Two additional sources provided references and inspiration for this project: (1) *Cone and Seed Insects of North American Conifers, by A.F. Hedlin, H.O. Yates III, D.C. Tovar, B.H. Ebel, T.W. Koerber and E.P. Merkel. Can. For. Serv./USDA For. Serv./Secr. Agric. Recur. Hidraul, Mexico. (1980)* and *(2) Cone and Seed Insects of Western Forest Trees, by F.P. Keen, USDA For. Serv. Tech. Bull. 1169.* (1958). The reader is referred to these publications for an excellent overview and summary of the cone and seed insects.

A real attempt was made to prepare as comprehensive a bibliography as possible. No doubt I have missed references, and I would be grateful if readers could bring these to my attention so that they can be included in the next edition.

Three indexes are provided at the end of the bibliography: taxonomic, not including parasites or predators or commensals; selected subject; and author or coauthor.

The literature review for this bibliography was completed in January 1985 and includes publications dated December 1983, or earlier.

ACKNOWLEDGEMENTS

I thank J.H. Borden, Simon Fraser University, Burnaby, B.C. for his comments and advice while this bibliography was in preparation, and for his constructive review of an earlier draft of this manuscript. My appreciation to W. Kaupp, L. Cadogan and G.E. Miller, Canadian Forestry Service, for their reviews, and S. Stitt for the excellent art work on the front cover.

Bibliography

1. Bringuel, G.J. 1968. Two new parasites of the Douglas-fir gall midge, *Contarinia oregonensis* Foote (Diptera: Cecidomyiidae). Pan-Pac. Entomol. 44:339-340.

Tetrastiches strobilus Burks (Hymenoptera: Eulophidae) and *Zachalochlora milleri* Crawford (Hymenoptera: Pteromalidae) were found in galls, and were thought to act as external parasites.

2. Buffam, P.E.; Johnson, N.E. 1966. Tests of guthion and dimethoate for Douglas-fir midge control. For. Sci. 12:160-163.

Significantly fewer *Contarinia oregonensis* and *Contarinia washingtonensis* Johnson, and less midge damage, was observed in cones from trees sprayed with 0.25% a.i. dimethoate after cones had closed and become pendant. Guthion and dimethoate applied when cones were open to receive pollen did not significantly reduce damage.

3. Chatelain, M.P.; Goyer, M.P. 1980. Seasonal attack period of cone-feeding insects of loblolly pine cones. Ann. Entomol. Soc. Am. 73:49-53.

To determine the seasonal attack period of cone-feeding insects, first and second year cones were caged to exclude insects. Those that were free from damage were then exposed for a 2-4 week period, then recaged and examined periodically for up to 45 days. Supplemental collections of damaged cones made at 2-4 week intervals corroborated the periods of attack determined by the exclusion study. Screen cages were effective in excluding insects; the only damage that occurred was abortion. The cause(s) of conelet abortion were not stated. Larvae of *Resseliella* sp. and *Asynapta* sp. were common in second year cones attacked by *Dioryctria amatella* (Hulst).

4. Coulson, R.N.; Franklin, R.T. 1968. Frequency of occurrence of cone-and seed-destroying insects on shortleaf pine in the Georgia Piedmont. J. Econ. Entomol. 61:1026-1027.

Over 11,000 cones were examined and 12.7% of these were found to be damaged by insects. Diptera were represented by three genera: *Hyperdiplosis*, *Lestodiplosis*, and *Mycodiplosis*, all members of Cecidomyiidae. Damage by these insects was confined to the second year cones; however no damage estimates were given. The number of damaged cones was related to the total number of cones/tree. In all cases where there were more than 90 cones per/tree some of these cones were attacked. Several trees having fewer than 90

cones were not attacked, suggesting that trees must bear a certain number of suitable cones before insects are attracted or become successfully established.

5. Dale, J.W.; Schenk, J.A. 1978. Cone production and insect-caused seed losses of ponderosa pine in Idaho, and adjacent Washington and Montana. For. Wild. and Range Exp. Stn., Univ. Idaho, Bull. 24.

Average seed loss from *Asynopta keeni* was never more than 1% of the total seed crop.

6. Dale, J.W.; Schenk, J.A. 1979. Bionomics and natural control of the cone and seed insects of Ponderosa pine in Idaho and adjacent Washington and Montana. For. Wild. and Range Exp. Stn., Univ. Idaho, Bull. 29, 24 pp.

Includes the bionomics of *Asynapta keeni* (Foote) (=*A. hopkinsi* Felt). Larvae of this species fed between cone scales but were also found under developing seed wings. No parasites or predators were found that could be exclusively associated with *A. keeni*. *A keeni* was found often associated with *Dioryctria* spp. In years of very small crops, heavy infestations might cause sufficient numbers of hollow or malformed seeds to be detrimental to those species feeding on seeds.

7. DeBarr, G.L.; Barber, L.R. 1975. Mortality factors reducing the 1967-1969 slash pine seed crop in Baker County, Florida--A life table approach. U.S.D.A. For. Serv. Res. Pap. SE-131. 16 pp.

The cone midge, *Resseliella silvana* (Felt) caused less than 1% damage to the cones of slash pine, *Pinus elliottii* Engel. var *elliottii*.

8. DeMars, C.J. 1964. Predicting insect caused damage to Douglas-fir seed from samples of young cones. U.S.D.A. For. Serv., Pac. Southwest For. and Range Exp. Stn., Berkeley, Calif. Note PSW-40. 7 pp.

No significant difference was found between early (July) and late (September) estimates of percent of total insect-damaged seeds by either the axial-slice or complete dissection method. Because of the difficulty in assessing all the seeds in heavily damaged cones, the author concludes that it would be better to count only the good seeds.

9. Dewey, J.E. 1972. A three year evaluation of Douglas-fir cone and seed insects in Montana and Yellowstone National Park. U.S.D.A. For. Serv., North. Reg., State and Priv. For., Rep. 72-1, 19 pp.

Contarinia washingtonenis and *C. oregonenis* together infested an average of 39, 17, and 25% of the cones in 1967, 1968 and 1970, respectively.

10. Dewey, J.E.; Jenkins, M.J. 1979. An evaluation of cone and seed insects in selected seed production areas in region 1 (Progress report I) U.S.D.A. For. Serv., North. Reg., State and Priv. For., Rep. 79-16, 18 pp.

The objectives of this evaluation were:

(1) Determine the primary cone-and-seed-feeding insects on a host basis, at each existing and presently planned seed production area in the region.

(2) Describe the type, and quantify the amount of injury caused by each insect species.

(3) Where possible, correlate extent of cone and seed injury with such factors as habitat type, elevation, stand age, and stocking density. Cone survey results from twenty existing or proposed seed production areas and one seed orchard are presented.

Asynopta hopkinsi were reared from Douglas-fir, ponderosa pine, and lodgepole pine. Adults of *Cecidomyia resinicoloides* Williams, *Cecidomyia* sp., *Lestodiplosis taxiconis* Foote, *Lestodiplosis* sp., and *Hopleginella conicola* (Greene) were reared from ponderosa pine.

11. Dewey, J.E.; Jenkins, M.J. 1980. An evaluation of cone and seed insects in selected seed production areas in region 1 (Progress report II). U.S.D.A. For. Serv., North. Reg., State and Priv. For., Rep. 80-18, 11 pp.

This second interim report presents the results of the cone insect damage surveys conducted in 1978 and 1979. Separate estimates of cone damage for each insect species are not given. The authors note that midges were the primary insect observed on Douglas-fir, western larch, ponderosa pine, and lodgepole pine.

12. Dewey, J.E.; Jenkins, M.J. 1982. An evaluation of cone and seed insects in selected seed production areas in region one (Final report). U.S.D.A. For. Serv., North. Reg., State and Priv. For., Rep. 82-5, 22 pp.

The objectives of the planned survey [see ref. 10] were not met because the project was terminated due to funding and manpower constraints. Insufficient data was available to establish relationships between cone injury and habitat type, stand age, stocking density and or elevation. On Douglas-fir, *Contarinia oregonensis* and *C. washingtonenis* were found to be widespread and abundant in all National Forests, whereas maggots, *Earomyia* sp., were common but unimportant. Midges, *Contarinia* sp., were found in cones of lodgepole and ponderosa pine. An unidentified midge and a cone maggot were responsible for part of the damage in western larch.

13. Dewey, J.E.; Meyer, H.E.; Parker, D.; Hayes, F. 1975. Ground application of dimethoate (Cygon) for control of cone and seed-destroying insects of Douglas-fir and grand fir. U.S.D.A. For. Serv., North. Reg., State and Priv. For. Rep. No. 75-13.

Dimethoate applied as 0.25 and 0.5% sprays in mid-June (single application) and mid-June and mid-July (double application) were evaluated for control of cone and seed insects in Douglas-fir and grand fir. Cone quality was determined using weight of cones, percent of cones showing visible injury, and number of sound seed per cut face of axial sliced cone. Although the applications were made 10 days later than desired, both the 0.25% treatments and the single 0.5% application significantly increased the sound seed of Douglas-fir. Inexplicably, the double application of 0.5% dimethoate failed to increase seed yield significantly. The only treatment resulting in significantly higher seed yielding grand fir was a single application of 0.25% dimethoate.

14. Ebel, B.H.; Gagne, B.H; Merkel, E.P., 1975. Cecidomyiidae from pine cones in Florida, with a generic key to larvae. Florida Entomol. 58:193-198.

Four cecidomyiids were reared from cone collections of slash pine, *Pinus elliottii* and longleaf pine, *P. palustris* from northern Florida. *Resseliella silvana*, (Felt) and possibly *Asynapta keeni*, were associated with primary cone damage, whereas *Mycodiplosis thoracica* (Fitch) was found on rust-infected cones. One specimen of *Lobodiplosis triangularius*, (Felt) was found and regarded as unimportant. An illustrated generic key to the larvae is given.

15. Ebel, B.H.; Flavell, T.H.; Drake, L.E.; Yates, H.O., III; DeBarr, 1980. Seed and cone insects of southern pines. U.S.D.A. For. Serv. Southeastern For. Exp. Stn. Gen. Tech. Rep. SE-8. 40 pp.

A revised version of an earlier (1975) publication. Presents a succinct overview of the biology, damage and importance of insects that limit seed production by the major pine species in the southeastern United States. Damage keys for flowers and conelets, cones, and seeds are given. Insect attack periods for each of the three categories are tabulated, as are the insect species and their pine hosts. Photographs, distribution maps and descriptions of the life stages are provided for 24 insects. Cone feeding midges (Cecidomyiidae) are discussed and given a distribution covering all of the southeastern United States.

16. Ebel, B.H.; Yates, H.O., III, 1974. Insect-caused damage and mortality to conelets, cones, and seed of shortleaf pine. J Econ. Entomol. 67:222-226.

The seasonal occurrence and relative abundance of insect-caused damage to cones and seeds over the two-year period of cone development is noted.

Unidentified cecidomyiid larvae caused an average of 3.8% conelet loss. Conelet mortality caused by midges varied widely, and of the 3.8% total loss 81% occurred on one tree. In 1968 cone mortality from cecidomyiid larvae was 25.0%, and 3.3% in 1969. Again, cone loss from midge damage occurred primarily on a single sample tree.

17. Fogal, W.H. 1979. Bionomic sketches of insects and fungal pests of cones and seeds of forest trees in Canada east of the Rockies. Can. For. Serv., Petawawa For. Exp. Stn., Inf. Rep. PS-X-72. 21 pp.

Bionomic sketches summarizing information on the geographic distribution, life cycle, damage and possible means of control for insect and fungal pests of spruce, pine, larch, hemlock, small-seed hardwoods and nut trees are presented with references.

18. Fogal, W.H.; Lopushanski, S.M.; Haddon, B. 1977. Insects attacking white spruce in three habitats. Proc. Entomol. Soc. Ont. 108:17-18.

From a survey of five trees (10-20 cones each) in each habitat (a) old field, (b) spruce-fir hardwoods, and (c) pure spruce stands, the incidence of attack by white spruce cone insect was assessed. *Pegohylemya (= Lasiomma)* sp. and *Dasineura rachiphaga* Tripp were found in all three habitats. Nearly four times as many cones were infested by *Pegohylemya* sp. in spruce stands than in old field spruce.

19. Foote, R.H. 1956. Gall midges associated with cones of western forest trees. (Diptera: Itonidae). J. Wash. Acad. Sci. 46:48-57.

Provides names and descriptions for a number of midges associated with cones of western forest trees. Describes both male and female adults of *Rhubsaamenia keeni* Foote (= *Asynapta hopkinsi*), *Dasyneura (= Dasineura) abiesemia* Foote, *Mycodiplosis conicola* Foote, *Mycodiplosis coryloides* Foote, *Lestodiplosis taxiconis* and *Contarinia oregonensis*, all of which were newly named species.

20. Franklin, R.T.; Coulson, R.N. 1968. Insects affecting seed production of shortleaf pine in the Georgia Piedmont. Can. Entomol. 100:807-812.

A general survey of the importance and occurrence of cone insects of shortleaf pine. Two orders of insects, Lepidoptera and Diptera (represented by *Hyperdiplosis*, *Lestodiplosis* and *Mycodiplosis* spp.) were found to be responsible for the majority of seed destruction. The three genera of Diptera were treated as one complex. The resinous coating caused by this complex was found to render the cone useless for extraction and accounted for a large part of the damage found (% damage not stated). The remainder of the paper is substantially a literature review of the species found.

21. Fye, R.E.; Wylie, W.D. 1968. Notes on insects attacking spruce and fir cones at Black Sturgeon Lake, Ontario. 1963-4. Can. Dep. Agric. Bi-Mon. Res. Notes 24(6):47-48.

Notes the presence of *Dasineura* spp. and cecidomyiids in white spruce cones collected in September.

22. Gagne, R.J. 1978. A new species of *Cecidomyia* injurious to cones of slash pine in Florida. Florida Entomol. 61:193-195.

The new species of pitch midge, *Cecidomyia bisetosa*, is the first to be reported feeding on cones: all other Cecidomyiids live in pitch

on twigs. Descriptions of the life stages are given and compared to its closest congener, *C. resinicola* (Osten Sacken). The specific epithet, *bisetosa*, is in reference to the presence of only two setae on each side of the terminal abdominal segment of the larvae.

23. Greathouse, T.E.; Allen, V.E.; Wright, K.H. 1960. Results of a field test to reduce insect damage to cones and seeds of Douglas-fir. U.S.D.A. For. Serv., Pac. Northwest For. and Range Exp. Stn. 5 pp.

Reports on preliminary field trials with the insecticide Sevin for control of *Contarinia oregonensis*. No proven method was found to control *C. oregonensis*. The paper recommends that the timing of Sevin applications be very precise - a few days prior to the time when conelets are at maximum receptivity for pollen.

24. Haig, R.A.; McPhee, H.G. 1969. Black spruce cone insect control trials, Longlac, Ontario, 1967-68. Can. Dep. Fisheries and Forestry, For. Res. Lab. Sault Ste. Marie, Ont., Inf. Rep. O-X-110. 9 pp.

Describes mistblower and hydraulic sprayer field trials with dimethoate, Meta-Systox, and DDT to control *Dasineura rachiphaga*, and an unnamed seed chalcid. Dimethoate applications made at the time of cone opening provided complete protection from insect attack.

25. Hedlin, A.F. 1958. Insects causing seed losses in Douglas-fir on Vancouver Island in 1957. Proc. Entomol. Soc. B.C. 55:37-39.

Provides a descriptive account of the biological studies initiated to determine the identity and importance of cone and seed insects of Douglas-fir. The groups of insects, the seed chalcids, cone moths, and gall midges, are described. It is noted in the descriptions of gall midges, that there is still uncertainty as to the identification of some species. Gall midge damage was an average of 4.4 seeds per cone with a maximum of 32 recorded in one cone. Midge infestation of cones ranged from 11-90%.

26. Hedlin, A.F. 1959. Description and habits of a new species of *Phytophaga* (Diptera: Cecidomyiidae) from western red cedar cones. Can. Entomol. 91:719-723.

This report presents the description and habits of a newly identified species of midge, *Phytophaga* (= *Mayetiola) thujae* (Hedlin), previously reported by Keen (1958) as an unidentified species. Photographs of male and female adults along with descriptions and figures of the features are presented. Adults of *P. thujae* are contrasted with the only other known species of *Phytophaga* attacking cones-- *Phytophaga carpophaga* Tripp. *P. carpophaga* differs from *P. thujae* in the male by having the stem of the fifth flagellar segment only about 1/3 as along as the node (3/4 as long in *P. thujae)* and in having the lobes of the tergite 10 much narrower and the notch of the sternite 10 much shallower than in *P. thujae.* Two species of Hymenopterous parasites, *Torymus* n.sp. and *Tetrastiches strobilus* were found. The life history of *P. thujae* is outlined.

27. Hedlin, A.F. 1959b. The effect of moisture and temperature on the emergence of the larvae of the Douglas-fir cone midge, *Contarinia oregonensis* Foote from cone scales. Can. Dep. Agric., Div. Forest Biol. Bi-Mon. Prog. Rep. 15:3-4.

Moisture is required before *Contarinia oregonensis* will emerge from the cone scales. Saturated cone scales (soaked in water for 6 hours) resulted in the highest emergence. Larvae will emerge at temperatures between 0° and 20°C, although they showed a preference for the lower temperatures.

28. Hedlin, A.F. 1961a. The life history and habits of a midge, *Contarinia oregonensis* Foote (Diptera: Cecidomyiidae) in Douglas-fir cones. Can. Entomol. 93:952-967.

Midge adults emerge from cocoons in early spring and deposit their eggs in newly opened female flowers. After eclosion the larvae enter the scales and form a gall near the ovules. Gall formation can prevent seed development or cause the seed and scale to fuse. Larvae leave the cones in late summer or fall during wet weather, drop to the ground where they spin cocoons in which to overwinter. Most of the cocoons can be found about half way between the base of the tree and the perimeter of the crown. The prepupal stage occurs from December to February, and the pupal stage lasts about 6 weeks. Each year about half of the population remain in diapause in the larval stage to emerge one or more years later.

An ectoparasite, *Torymus* sp. and an endoparasite *Platygaster* sp. var *americana* were noted.

29. Hedlin, A.F. 1961b. Some aspects of the cone and seed insect problem in the Pacific Northwest. For. Chron. 37:6-9.

A descriptive account of the importance of cone and seed insects, of the history of cone and seed insect research, and of the types of damage caused by insects. The author emphasizes the importance of developing good sample methods and understanding the biology, ecology and population dynamics of the insects in order for management programs to be effective.

30. Hedlin, A.F. 1962a. Attraction of Douglas fir flowers to cone insects. Can. Dep. Agric., Div. Forest Biol., Bi-Mon. Prog. Rep. 18:4.

There was no indication that *Contarina oregonensis* or *Barbara colfaxiana* had a preferential attraction to flowers that ranged in colour from green, to various shades of rose to crimson.

31. Hedlin, A.F. 1962b. Two systemic insecticides phosphamidon and systox used against the Douglas fir cone midge *Contarinia oregonesis* Foote. Can. Dep. Agric., Div. Forest Biol., Bi-Mon. Prog. Rep. 18:3-4.

Preliminary experimental studies indicated that phosphamidon and Systox are capable of killing the cone midge; however further studies on the concentration, time, frequency of spray applications were considered necessary.

32. Hedlin, A.F. 1964a. Life history and habits of a midge, *Phytophaga thujae* Hedlin (Diptera: Cecidomyiidae) in western red cedar cones. Can. Entomol. 96:950-957.

This report follows up an earlier report by Hedlin (see ref. 26, editor) on this species. The adult midge emergence period commences early in March following pollination of female flowers. Eggs laid in early spring incubate for nearly one month. Newly emerged larvae are present from mid-April to mid-May. Larvae feed in seeds and scales. In late summer when feeding is complete the mature larvae spin a cocoon on the cone scale. The prepupae and pupal stages last approximately 2 and 2½ months, respectively. The parasites *Torymus* sp. and *Tetrastiches* sp. are responsible for reducing the larval population by more than 1/3. There is high mortality (62%) at the egg and first-instar stage. This midge is considered to be an effective seed destroyer because it feeds on several fertile seeds within the productive zone of the cone.

33. Hedlin, A.F. 1964b. A six-year plot study on Douglas fir cone insect population fluctuations. For. Sci. 10:124-128.

Population fluctuations of *Contarinia oregonensis* in relation to cone crop size were found to be extreme. It is suggested that without some knowledge of the potential insect emergence (i.e., what proportion of the population will remain in diapause) in addition to the expected cone yield, cone-insect damage would be difficult to predict.

34. Hedlin, A.F. 1964c. Five systemic insecticides used against Douglas-fir cone insects. Can. Dep. Agric., Forest Biol. Div., Bi-Mon. Prog. Rep. 20:4.

Of the five systemic insecticides tested (bidrin, dimethoate, numbered compound C-43064, phosphamidon, and demeton), bidrin was the most effective for insect control. However, when both insect control and phytotoxicity were considered dimethoate was regarded as being the best overall insecticide. This study suggests that it is apparenty necessary to treat the entire cone-bearing portion of the crown and to treat the cones when they are at or near the pendant stage.

35. Hedlin, A.F. 1966. Prevention of insect-caused seed loss in Douglas-fir with systemic insecticides. For. Chron. 42:76-82.

Bidrin (0.35 and 0.75%), dimethoate, Meta-Systox, Sumithion, and SD 9129, all at 1.0 and 2.0%, were evaluated for control of *Contarinia oregonensis, C. washingtonensis, Barbara colfaxiana,* and *Megastigmus spermotrophus* Wachtl. All insecticides except Sumithion gave good protection when applied as sprays to cones and foliage. The report recommends that to give complete coverage of cones and foliage, insecticides should be applied when cones are near or at the pendant stage of development.

36. Hedlin, A.F 1967. Cone insects of grand fir, *Abies grandis* (Douglas) Lindley, in British Columbia. J. Entomol. Soc. B.C. 64:40-44.

Information on the life history, habits and damage caused by insects of grand fir is presented. Three species of midge, a scale midge, a cecidogenus midge, and a seed midge were noted but not identified. *Earomyia abietum* McAlpine was found, and an indirect loss of five seeds per cone was attributed to this insect.

37. Hedlin, A.F. 1973. Spruce cone insects in British Columbia and their control. Can. Entomol. 105:113-122.

Describes the life histories and habits of the insects of white and engelmann spruce in British Columbia and evaluates insecticides for control of these insects. *Lasiomma (= Hylemyia) anthracina* (Czerny) emerge in May and early June and deposit eggs singly between the young cone scales. Larvae leave cone scales from 20 July until 5 August. *H. anthracina* and *Cydia (= Laspeyresia) youngana* (Kearfott) are the two most important seed destroying insects. One *Hylemia anthracina* larvae can destroy an average of 31 seeds, or about 55% of the potential seeds. The percentage of cones infested with this insect was 13 and 38% in 1968 and 1969, respectively. *Dasineura rachiphaga* attacked about 32% of the cones of both species. *Dasinura canadensis* Felt attacked about 24% of the cones, but did little damage to the seeds. *Mayetiola carpophaga*, and *Resseliella* spp. are noted. A number of useful photographs illustrate life stages and damage; a drawing shows the typical feeding sites of the insects. Dimethoate at 1.0 and 0.5% was effective for control of *Hylemyia* and *Laspeyresia*. Formothion was less effective and oxydemetonmethyl and dicrotophos were much less effective than dimethoate. The insecticides did not affect seed germination.

38. Hedlin, A.F. 1974. Cone and seed insects of British Columbia. Environ. Can., Can. For. Serv., Pacific For. Res. Cent. Inf. Rep. BC-X-90. 63 pp.

This 63-page handbook provides damage keys, illustrations and distribution maps for the more important cone and seed insect pests on 15 species of trees in British Columbia. A section on the prevention and control of cone and seed insects is provided. Host, damage, description, life history and additional literature references are given for each insect species.

39. Hedlin, A.F. 1974. Spruce cone insects in British Columbia. Can. For. Serv., Pac. For. Res. Cent., Leaflet. 4 pp.

Cone damage by *Dasineura canadensis, D. canadensis, Lasiomma (= Hylemia) anthracina, Mayetiola carpophaga,* and *Resseliella* sp. is illustrated in this leaflet.

40. Hedlin, A.F. and C.Y. Hovey. 1954. Prairie provinces: cone insects. Can. Dep. Agric., Forest Biol. Div., Bi-Mon. Prog. Rep. 10:3.

A short qualitative list of insects found in spruce and pine cones found at the Forest Nursery Station, Indian Head Saskatchewan. Notes the abundance of *Dasineura canadensis* (common), *Rhabdophaga* sp. (few). An unidentified species of Itonididae (= Cecidomyiidae) sp. (few) on white spruce is noted.

41. Hedlin, A.F.; Johnson, N.E. 1963. Life history and habits of a midge, *Contarinia washingtonensis* Johnson (Diptera: Cecidomyiidae), in Douglas fir cones. Can. Entomol. 95:1168-1175.

Adult midges emerge from cocoons in the litter between mid-May and the end of June. Oviposition continues for about one month and egg hatch occurs about one week after oviposition. Eggs are laid between the bract and scale of the cone. Larvae pass through three instars and feed on the cone scales, often killing the scales before maturity. Larvae leave the cones and drop to the ground in late summer or early fall. About 50% of the overwintering larvae remain in diapause the first year. Up to 47% of the seed has been recorded as damaged in western Washington. *Earomyia barbara* was observed feeding on the larvae, and a hymenopterous endo-parasite, probably *Platygaster*, was found.

42. Hedlin, A.F. and N.E. Johnson. 1968. A new species of *Camptomyia* (Diptera: Cecidomyiidae) from Douglas fir cones. Can. Entomol. 100:532-535.

Descriptions of larva, pupa, and male and female adults are given for this new species, named *Camptomyia pseudotsugae* Hedlin and Johnson. Adults can be distinguished from all other species of midges in Douglas-fir cones by the venation of their wings, which have a distinct crossvein (Rs) uniting vein 3 and the sucostal vein. Larvae emerge from cones in the fall and overwinter in the litter. Pupation takes place in late May or early June, and adults emerge in June to lay their eggs. Larvae pass through three instars.

43. Hedlin, A.F.; Ruth, D.S. 1977. Comparison of germinability of seed from insect-infested and uninfested cones. Can. For. Serv., Bi-Mon. Res. Notes 33-34.

There was no appreciable difference in germinability between seed from Engelmann spruce cones infested with *Lasiomma anthracina* and from uninfested cones.

44. Hedlin, A.F.; Ruth, D.S. 1978. Examination of Douglas-fir clones for differences in susceptibility to damage by cone and seed insects. J. Entomol. Soc. B.C.75:33-34.

Although significant differences in the percent of damaged seeds were detected among the clones, the differences were not large enough to be of practical significance. Damage caused by *Contarinia oregonensis* and *C. washingtonensis* was included in this study.

45. Huckett, H.C. 1953. A new species of the Anthomyiid genus *Hylemyia* Rob. Desv. from Oregon, reared from fir cones (Muscidae, Diptera). Brooklin Entomol. Soc. Bull. 48:107-110.

Provides descriptions for the new species *Hylemyia (=Lasiomma) abietus* Huckett.

46. Huckett, H.C. 1965. The Muscidae of northern Canada, Alaska, and Greenland (Diptera). Mem. Entomol. Soc. Can. 42. 369 pp.

Keys for the species of the subgenus *Lasiomma* (includes *L. abietus* and *L. anthracina)* are given on pages 104-105 for both male and female flies.

47. Johnson, N.E. 1958. Insect damage to the 1957 Douglas-fir seed crop on Weyerhaeuser Timber Company tree farms. Weyerhaeuser For. Res. Note 18. 9 pp.

Cone samples taken from 44 areas on 8 tree farms in western Washington and Oregon were analyzed. The total and relative effects of insects were determined to develop guidelines for priorities on studies of insect biology and control. Gall midges were present in 43% of the sample cones and destroyed 63% of the seed. *Contarinia oregonensis* was responsible for most of the damage. The author noted that when the pink larvae of *C. oregonensis* emerge from the cone they are often seen "jumping." An unidentified species was observed to mine the cone scales.

48. Johnson, N.E. 1962a. Distribution of Douglas fir cone midges in the forest litter beneath young, open-grown Douglas fir. Can. Entomol. 94:915-921.

Forest litter and soil samples were taken at the base of the tree, halfway between the base and the edge of the crown, at the edge of the crown, and at 2, 4, and 6 feet beyond the edge of the crown, to determine the distribution of Douglas-fir cone midges. Most larvae were found under the edge of the crown and in the upper layer of the litter. Larvae were concentrated on the base of the male flowers and between fallen leaves. It is suggested that larvae move to the tree crown edge by "jumping" because of their attraction to light. Larvae overwinter in the forest litter beneath the tree from which they originate.

49. Johnson, N.E. 1962b. A possible sampling method for determining when to spray for control of the Douglas fir cone midge. Weyerhaeuser Res. Note 49. 10 pp.

This paper provides a rough guideline on when to spray based on estimates for the number of midges per sq. ft. of litter and the number of cones on the southerly branch in each whorl.

50. Johnson, N.E. 1962c. Tests of Guthion for the control of the Douglas fir cone midge. J. Econ. Entomol. 55:613-616.

Spray concentrations of 0.02, 0.08, 0.32, and 1.28% active Guthion by weight were effective in reducing the number of cone midges per cut cone face. Conelet abortion was reduced significantly from 98% in the untreated controls to less than 28% in the cones receiving the highest dosage of Guthion. It is suggested that cone midges in addition to damaging seed may also cause cones to die prematurely.

51. Johnson, N.E. 1963a. Time of attack of the Douglas fir cone midge in relationship to cone development. J. For. 61:350-355.

The cone midge, *Contarinia oregonensis*, attacks only when the conelet is open for pollination. This period usually lasts 7-10 days but may be extended by cold weather. Cone development stages are illustrated and can be used to predict time of attack. Additional indicators of attack period are when fiddleheads, *Pteridium aquilinum*, are 3-12 in. in height with the fronds still tightly folded. Hopkins bioclimatic law was found to be of little use in the areas studied.

52. Johnson, N.E. 1963b. Cone scale necrosis and seed damage associated with attacks by Douglas fir cone midge. For. Sci. 9: 44-51.

Cone scale necrosis did not affect the germinability of sound seed that survived attack by *Contarinia oregonensis* or *C. washingtonensis*. Reducing sugar content associated with seed maturation was not altered by cone scale necrosis.

53. Johnson, N.E. 1963c. Insecticides tested for control of the Douglas fir cone midge. J. Econ. Entomol. 56:236-237.

Guthion, Sevin, endosulfan, dimethoate, and phorate, applied as a 0.5% active ingredient by weight sprayed on individual cones with a hand atomiser, significantly reduced the number of cone midges per cone slice.

54. Johnson, N.E. 1963d. Helicopter application of Guthion for control of the Douglas-fir cone midge. J. Econ. Entomol. 56: 600-603.

The reduction in the number of midges per cone was highest in the top part of the trees' crown that received the highest dosage. Deposits as measured on paper cards were highly variable and ranged from 0.0 to 2.08 lb of insecticide/acre based on spectrophotomic analysis of the extracts from the cards. The highest rate of deposit, 2.08 lb/acre, reduced the midge population by 80%. It is suggested that an application of 8.0 lb/acre of insecticide would appear to be necessary to obtain a deposit of at least 2.0 lb/acre in all portions of the tree. Because of the apparent need for such high rates, helicopter application of Guthion could not be recommended at the time.

55. Johnson, N.E. 1963e. *Contarinia washingtonensis* ((Diptera: Cecidomyiidae), new species infesting the cones of Douglas-fir. Ann. Entomol. Soc. Am. 56:94-103.

Descriptions of the holotype (male), allotype (female) and paratypes (males, females, larvae, pupae and eggs) are given for the new species, *Contarinia washingtonensis*. *Contarinia oregonensis* species were larger than *C. washingtonensis*. For example, the width/length ratio, both disti- and basi-style, and the length/width, prox. node node 5th antennal reg. were larger for *C. oregonensis*. Additional comparative ratios of various insect parts are provided that help distinguish these species. The habits of

these two species were also different. *Contarinia oregonensis* attack cones when they are newly opened for pollination, inhabit the area beneath and surrounding the seed causing a gall to form, and leave the brown cones after the fall rain. *Contarinia washingtonensis*, on the other hand, attack the cones when they are closed and pendant; mine the cone scale and do not cause gall formation; and leave the cones before the fall rains while the cones are still somewhat green.

56. Johnson, N.E. 1964. Chemical control of the Douglas fir cone midge, *Contarinia oregonensis*, using a mistblower from a truck-mounted ladder. J. Econ. Entomol. 57:556-558.

Cone midge populations were reduced by about 74% in cones treated with 1.0% formulations of Guthion and Thiodan (endosulfan). Seed yield increased by 250% over untreated cones. However conelet abortion was higher among treated cones than among untreated cones: the 1.0% spray concentration being the probable cause. It is recommended that 0.25-0.50% concentrations of insecticides be evaluated.

57. Johnson, N.E.; Hedlin, A.F. 1967. Douglas fir insects and their control. Can. Dep. For. Rural Dev., For. Branch Dep. Publ. 1168. 11 pp.

Summarizes the results of chemical control studies conducted by the Weyerhaeuser Company and the Canadian Forestry Service. Presents the life history and habits of Douglas-fir cone and seed insects including Douglas-fir cone midge and Douglas-fir scale midge. The need for control, when to spray, what chemical insecticides to use, how to mix and to apply chemical insecticides are discussed.

58. Johnson, N.E.; Heikkenen, H.J. 1958. Damage to seed of Douglas fir cone midge. For. Sci. 4:274-282.

The title is somewhat misleading because the paper also provides descriptions of the immature stages of the midge, *C. oregonensis*, and important details of its biology, which at the time (1958) had not previously been reported. Detailed descriptions of the egg, larva, pupa, and adults are given. Adults emerge in the spring when Douglas-fir conelets are open and the female lays her eggs singly or in clusters on the developing cone scales near the seed. Larval feeding begins on or near the cone scale and is followed by a gall formation in which the larvae become encased. Larvae

usually emerge from the cone late in the fall, and upon reaching the forest floor form a cocoon in the litter. When numerous larvae congregate around a seed the resulting aggregate gall may completely destroy or replace the seed. As much as 99% of galled seed may remain in the cone during processing. The less time-consuming cone-slicing was found to be as accurate in estimating percent seed damage as the seed extraction method.

59. Johnson, N.E.; Meso, S.W. 1966. Effectiveness of three systemic insecticides for Douglas fir cone and seed insect control. Weyerhaeuser For. Pap. 10. 10 pp.

Bidrin, dimethoate, and Meta-Systox® applied at concentrations of 0.5 and 1.0% to cones at the pendant stage effectively controlled *Contarinia oregonensis* and *C. washingtonensis*.

60. Johnson, N.E.; Rediske, J.H. 1964. Tests of systemic insecticides for the control of the Douglas fir cone midge, *Contarinia oregonensis* Foote. Weyerhaeuser For. Res. Note 56. 13 pp.

Describes a technique developed to test systemic insecticides. Several insecticides can be injected into the same tree provided each test branch is girdled between the base and the point of injection. Using this method, a comparison of the effectiveness of several systemic insecticides was made between individual branch injection and individual cone sprays. The individual stem injection method was found to be more effective for control of the midge than the individual cone spray method. Of the 10 insecticides tested, dimethoate gave the best control.

61. Johnson, N.E.; Rediske, J.H. 1965. A test of systemic insecticides to control Douglas fir cone and seed insects. J. Econ. Entomol. 58:1020-1021.

Ten insecticides were tested. Individual branch injections were generally more effective in controlling *Contarinia oregonensis* and *C. washingtonensis* than aqueous insecticide mixtures sprayed on cones. However cones from branches injected with insecticides were, on the average shorter, and contained fewer good seeds than those from sprayed branches. This reduction in length was attributed to the phytotoxic effect caused by the chemicals.

62. Johnson, N.E.; Winjum, J.K. 1960. Douglas fir cone and seed insect biological and control studies: progress in 1958, 1959. Weyerhaeuser For. Res. Note 22. 23 pp.

A detailed account of biological and control studies conducted by the Weyerhaeuser Company. The study provides a useful review of the literature, a key to the insects found in green Douglas fir cones, and a review of the preliminary insecticide tests conducted. A section is included on the precautions to take in the use of modern insecticides.

63. Johnson, N.E.; Zingg, J.G. 1967. Effective translocation of four systemic insecticides following application to the foliage and cones of Douglas fir. J. Econ. Entomol. 60:575-578.

Thorough coverage of the foliage with 0.5-1.0% concentrations of Bidrin, Azodrin, methyl demeton, or dimethoate is recommended for control of the insects affecting seed production in Douglas-fir. Phytotoxicity was higher in foliage than in cones and increased with insecticide concentration. Rapid and effective movement of all of the four insecticides from the foliage into the cones was observed. Effective translocation, judged on the ratio of the dead to living insects, did not occur from one side of the cone to the other, or from the tip of the cone to the base.

64. Kinzer, H.G.; Ridgill, B.J.; Watts, J.G. 1972. Seed and cone insects of ponderosa pine. New Mexico State Univ. Agric. Exp. Stn. Bull. 594. 36 pp.

Summarizes the findings of a study to identify the seed and cone insect of ponderosa pine in New Mexico. The biology, distribution, economic importance, time of emergence and the time of attack of the major insects is given. A total of 69 different insects were found associated with ponderosa pine. The following Diptera were reported to feed on cones: (asterisk indicates that life stages and history are described in the text), *Asynapta keeni (=hopkinsi)**, *Cecidomyia* sp.*, *Contarinia* sp., *Lestodiplosis* sp., *Lestodiplosini* genus (probably new), *Mycodiplosis* near *conicola**, *Thomasiniana* sp.*, *Leucopis* sp., *Hapleginella conicola*, *Oscinella* n. sp., *Tricimba* n. sp., and *Coniosciella* n. sp.

65. Koerber, T.W. 1960. Insects destructive to the Douglas fir seed crop in California ... a problem analysis. U.S.D.A. For. Serv., Pac. Southwest For. and Range Exp. Stn., Tech. Pap. 45. 36 pp.

This paper reviews the state of knowledge of the life history and habits of the insects, sampling methods, and control methods; and suggests additional research required in these areas. Useful lists are provided of the insects known or suspected to be destructive to cones and seeds of Douglas-fir, and of the parasites and predators of these insects.

66. Koerber, T.W. 1963. Insecticide tests on the Douglas fir cone midge, *Contarinia oregonensis* Foote. Can. Entomol. 95:640-641.

Experiments were conducted to determine the effectiveness of residual insecticides applied to the surface of the duff before adult midge emergence. Artificially infested duff blocks (9x9 in.) were treated with either Lindane, dieldrin, or Sevin, in a spray chamber. The nominal application rate was 1.5 lbs/acre. After treatment the duff samples were returned to the field where they were covered with a trap to determine the number of adults emerged. Lindane reduced emergence by 98.5%. It was noted, however, that the relative effectiveness of the materials tested fell in the same pattern as their relative vapour pressures, suggesting that some insecticides may have had a fumigant effect. Some shortcomings of the duff treatment method were recognized; namely that *Platygaster*, an endo-parasite, would also be killed and that the effectiveness of duff treatment might be affected by the migration of insects from untreated areas. It is suggested that the area be extended beyond the seed production area to reduce the invasion from insects outside the area.

67. Koerber, T.W. 1978. Tests of bole-injected systemic insecticides for control of Douglas fir cone insects. pp. 323-329 *in* Flowering and seed development of trees. Proc. Mississippi State Univ., May 15-18, 1978.

Using preloaded injector units, the efficiency of individual tree treatments with 0.25, 0.5 and 1.0 g Meta-Systox R, and 0.25 and 0.5 g Orthene per 2.5 cm tree circumference were evaluated for control of *Contarinia oregonensis*. All of the treatments reduced the average number of seeds destroyed by insects; however increases in sound seeds were obtained at only two of the three test sites and the tree boles were damaged at the point of injection. The report cautions that if stem injections are made repeatedly on the same tree the progressive accumulation of pitch-impregnated sapwood would interfere with normal water movement and the transport of further systemic insecticide injections.

68. Koerber, T.W. 1979. Bole-injected systemic insecticides for control of Douglas fir cone insects. pp. 259-302 *in* Systemic Chemical Treatments in Tree Culture Symposium. Proc. Kellogg Centre Continuing Education, Mich. State Univ. East Lansing.

Metasystox-R in methyl isobutyl ketone applied at 0.25, 0.50 or 1.00 g of a.i. per inch of tree circumference, Orthene in 50% ethanol and Orthene in 50% acetone applied at 0.25 or 0.50 g a.i. per inch of tree circumference were injected into boles of Douglas-fir for control of *Contarinia oregonensis*. Efficacy results were inconclusive due to high tree to tree variability in sound seed yield. Lesions were observed in the sapwood and thought to be caused by the insecticide solvents rather than the insecticides themselves. The paper notes that the possibility of long range cumulative adverse effects on the trees from repeated injections warrants further investigation.

69. Kozak, A. 1964. Sequential sampling for improving cone collection and studying damage by cone and seed insects in Douglas fir. For. Chron. 40:210-218.

Sequential sampling plans for determining the production of filled seed and damage are described and presented for individual trees and stands of Douglas-fir. The author concludes that sequential sampling to define Douglas-fir cone quality and to select individual trees for cone collection are efficient and effective. It is suggested that sampling based on cone quality of individual trees should not be used to determine the infestation level in stands because of the high tree to tree variation.

70. Kulhavy, D.L.; Schenk, J.A. 1976. An evaluation of damage by cone and seed insects of grand fir in northern Idaho. Dep. Entomol. Univ. Idaho, Anniv. Publ. 5:27-35.

Asynapta keeni was the most prevalent of 51 species of insects collected from *Abies grandis* cones, however only 0.9 and 1.4% of the cone damage was attributed to this species in 1970 and 1971 respectively. Two *Dasineura* sp., designated as 'A' and 'B' were noted. *Dasineura* sp. B did not cause any discernable damage, while *Dasineura* sp. A accounted for 2.6% of the cone damage in 1970. *Earomyia* sp. caused less than 1% of the insect damage in 1970 and 1971. Cone damage by *Lasiomma (=Hylemyia) abietis* was 9.8% in 1971.

71. Kulhavy, D.L.; Schenk, J.A. 1976. Cone and seed insect damage and prediction of cone production in grand fir in Potlatch area of northern Idaho. Forestry, Wildlife and Range Exp. Stn., Univ. Idaho. Stn. Note 23. 6 pp.

A method for predicting cone production in grand fir (on the basis of one year's data when cone production was exceptionally poor) is presented. The regression equation predicted cone production on the basis of the number of cones visible on the top two whorls, and the number of cones visible in the south side of the crown. In the cone survey conducted, *Dioryctria abietella* and *Lasiomma (=Hylemyia) abietis* accounted for about 90% of the insect damage and destroyed about 6% of the seeds.

72. Kulhavy, D.L.; Dale, J.W.; Schenk, J.A. 1975. A checklist of the cone and seed insects of Idaho. Forestry, Wildlife and Range Exp. Stn., Univ. Idaho Current Inf. Ser. 6. 28 pp.

This checklist is presented in two parts: (1) the insects by host tree, the life stages of insects collected, and the specialist who identified the specimens, and (2) by insects and their host tree. Within the order Diptera the following families are listed: Acroceridae, Athomyiidae, Cecidomyiidae, Chamaemyiidae, Chlorophilidae, Drosophilidae, Lonchaeidae, Phoridae, Piophilidae, Sciaridae, Syrphidae, and Tachinidae.

73. Kulhavy, D.L.; Schenk, J.A.; Hudson, T.J. 1976. Cone and seed insects of subalpine fir during a year of low cone production in northern Idaho. J. Entomol. Soc. B.C. 73:25-28.

A new species of *Dasineura* was found that destroyed 11% of the seed crop. *Lasiomma (=Hylemyia) abietis*, *Asynapta keeni*, and an *Earomyia* sp. caused 0.3, 0.4, and 1.3% damage to the seed, respectively. The number of seeds within subalpine fir cones could be reliably estimated from cone length; and the number of damaged seeds per cone could be estimated from counts of damaged seeds on an axial slice ($r = .6777$, $a = 0.01$). Radiography or seed dissection is recommended to account for damage caused by internal seed feeders.

74. Lyons, L.A. 1957. Insects affecting seed production in red pine. III. *Eucosma monitorana* Heinrich, *Laspeyresia toreuta* Grote (Lepidoptera: Olethreutidae), *Rubsaamenia* sp. (Diptera: Cecidomyiidae), and other insects. Can. Entomol. 89:150-164.

Damage by a cecidomyiid, *Rubsaamenia (=Asynapta)* sp., was very light, but on a few occasions exceeded 40% in red pine cones. Cone attack began in June, but attack was at first hard to recognize. Cone damage for this cecidomyiid can be diagnosed by the presence of white resin flakes, and by the absence of debris left by cone worms and cone beetles. The parasite *Tetrastices* sp. was found emerging from the host puparia in spring or early summer. *Oscinella (=Hapleginella)* sp. (near *conicola)* was found to feed coprophagously in dead red pine cones recently killed by *Conophthorus resinosae.* A species of *Lestodiplosis* was also found associated with *C. resinosae.*

75. McAlpine, J.F. 1956. Cone-infesting lonchaeids of the genus *Earomyia* Zett., with descriptions of five new species from western North America (Diptera: Lonchaeidae). Can. Entomol. 88:178-196.

Presents the taxonomy and nomenclature of the adults of five species in the genus *Earomyia* reared from cones. A key to the adults of *Earomyia abietum, E. aquilonia* McAlpine, *E. barbara, E. brevistylata* McAlpine, and *E. longistylata* McAlpine, is given along with a collection of the known habits of these insects. A number of basic biological traits of this group of lonchaeids were apparent: (1) several species may live in the same cone at the same time, (2) some species require 2-3 years to complete their life cycle, whereas others mature in one year, (3) some species feed in cones of a single conifer species and others are adapted to a number of different conifer species, and (4) each species has a different distribution, probably related to the range of the host tree or trees.

76. McAlpine, J.F.; Steyskal, G.C. 1982. A revision of *Neosilba* McAlpine with a key to the world genera of Lonchaeidae (Diptera). Can. Entomol. 114:105-137.

Provides a much needed key to the genera.

77. McLeod, P.J.; Yearian, W.C. 1981. Insects associated with pine seed production in Arkansas. Agric. Exp. Stn., Univ. Arkansas. Bull. 850. 40 pp.

This bulletin compiles the data from research studies conducted on a discontinuous basis in Arkansas over a period of 15 years and presents it in a form suitable for seed orchard managers. Insect species identified on slash, loblolly, shortleaf and longleaf pine

are presented according to the host structure on which they feed, (1) strobili, (2) vegetative shoots and buds, or (3) foliage. The biology, impact, and the results of numerous control trials (for *Dioryctria* and *Laspeyresia* spp.) are provided. The cone feeding midge, *Asynapta hopkinsi* were found in all plant material, but was most abundant on shoots and second year cones of loblolly pine. Very few shoots or cones were completely destroyed by this insect.

78. Miller, G.E. 1980. Pest management in Douglas fir seed orchards in British Columbia: a problem analysis. Simon Fraser Univ., Pest Management Paper 22. 138 pp.

An exhaustive review of the literature as well as personal communication with people involved in Douglas-fir seed production forms the basis of this problem analysis of the complex of pests of Douglas-fir seed orchards in British Columbia. Cone and seed insects were found to be the most important seed destroyers, and lepidopterous borers of graft unions have been a chronic problem in B.C. Other potential pests reviewed include, the heartrotting and rootrotting fungi, dwarf mistletoe, moulds, barkbeetle, Cooley spruce gall aphid, scales, mites, squirrels, rabbits, mice, and deer. Sampling methods and damage prediction are examined for cone and seed insects, for defoliators, and for chronic and occasional pests. Biological, chemical, and cultural control tactics are evaluated for pathogens, insects and vertebrates.

79. Miller, G.E. 1982. Phytotoxicity to Douglas fir megastrobili and efficiency against Douglas fir cone gall midge of five fatty acid derivatives. Can. J. For. Res. 12:1021-1024.

The fatty acid derivatives, Potassium oleate, Potassium caprate, Potassium undecylenate, Methyl coconate, and Lauryl alcohol were found to be unsuitable for use in Douglas-fir seed orchards for control of *Contarinia oregonensis*. Only Potassium oleate caused significant reductions in gall midge damage, but did not increase the number of filled seed and was phytotoxic to megastrobili.

80. Miller, G.E. 1983. Evaluation of the effectiveness of cold-water misting of trees in seed orchards for control of Douglas-fir cone midge (Diptera: Cecidomyiidae). J. Econ. Entomol. 76: 916-919.

Cold water misting in seed orchards to prevent pollen contamination by delaying bud burst was evaluated as a method of control of *Contarinia oregonensis*. The greatest reduction in damage, up

to 99.2% in one seed orchard, occurred when delays of 10 days coincided with the early flowering trees being the most heavily attacked. No reductions occurred when delay was less than or equal to 5 days or when trees flowered during the middle of the flowering period. Because delay in bud burst is determined by weather and varies from year to year, and because the synchrony between the presence of the adult midge and susceptible host stage is not consistent, it was not possibe to predict the efficacy of misting.

81. Miller, G.E.; Borden, J.H. 1981. Evidence for a sex pheromone in the Douglas fir cone gall midge. Can. For. Serv. Res. Notes 1:9-10.

Living adult midges, used as test lures, were placed in cages and inserted into a sticky trap. These traps were located in the top, middle and bottom third of the tree crowns in seed orchards. Laboratory studies showed however, that female midges seldom flew before they were mated and that mating occurred at ground level. Furthermore, since cone harvest in seed orchards results in the removal of immature midges leaving few on-site adults to emerge the following year, the traps were relocated to Douglas-fir plantations and placed 2-3 cm above the ground. Traps baited with virgin females captured significantly more males than nonbaited (control) traps, indicating that females produce a pheromone. The usefulness of using pheromone traps to monitor insect populations and to predict damage is discussed.

82. Miller, G.E. and D.W. Hutcheson. 1981. Aerial spraying for control of the spiral spruce-cone borer, *Hylemyia anthracina* (Diptera: Anthomyiidae). J. Entomol. Soc. B.C. 78:3-6.

Three aerial application techniques: (1) broadcast with a 48-nozzle boom, (2) individual tree spraying with a 5-nozzle boom, and (3) individual tree spraying with a 6-nozzle 'A' frame boom, were evaluated for effectiveness in controlling *Lasiomma (=Hylemyia) anthracina* with dimethoate. Population reductions of 100, 87, and 68% were achieved with the 'A' frame, 5 nozzle individual tree, and 48-nozzle broadcast applications, respectively. All applications were made when the megastrobi were closed and turning to just past the horizontal position. Increased seed yields were 22 and 43% per cone for the broadcast and individual tree treatments, respectively.

83. Morley, W.J. 1948. Insects inhabiting the cones of white spruce. Can. Dep. Agric. For. Insect Div., Bi-Mon. Prog. Rep. 4:2.

A survey of cones received by the seed extraction plant at Angus, Ontario was initiated in late May to determine their insect fauna. Numerous Cecidomyiids were found and are described by larval colour and feeding habits. Anthomyiid larvae were found in cones examined before late June. Endo- and ecto-parasites of the Cecidomyiids were noted.

84. Neel, W.W.; Sartor, C.F. 1969. Notes on insects infesting pine cones in Mississippi. Entomol. News 80:159-167.

Cones collected from recently felled trees in six counties in Mississippi were examined for the presence of insects. *Asynapta* spp. were considered to be primary insects of loblolly, shortleaf, and longleaf pine but not of slash pine. One species of *Asynapta*, identified as *Asynapta* near *keeni*, caused damage to the inner tissue of the cone scale and to young seed.

85. Overhulser, D.L.; Yanaka, Y. 1983. Insect damage to noble fir seed and the feasibility of protecting cone crops in natural stands. For. Sci. 29:112-116.

Earomyia spp. and *Dasineura* spp. were found to be the principle pest species of noble fir. Stem injections of acephate reduced insect damage significantly, however the reduction resulted in a concomitant increase in empty rather than filled seed. A phytotoxic effect of acephate is considered unlikely and the authors cite four factors that may be responsible for empty seed. Observations of the micropyles revealed the presence of small elongated objects, very probably insect eggs or foreign pollen. It is suggested that if insect activity interferes with the fertilization process, then the application of systemic insecticides would not be of benefit because it would not prevent oviposition activity.

86. Pettinger, L.F.; Johnson, N.E. 1962. The influence of overwintering site of the mortality of the Douglas fir cone midge, *Contarinia oregonensis* Foote. Weyerhaeuser For. Res. Note 45. 5 pp.

Forest litter containing male cones was found to provide a better overwintering site for larvae of the midge than litter without male cones. The paper suggests that sampling of male cones would probably provide a sound estimate of the midge population.

87. Pfister, R.D.; Woolwine, P.C. 1963. Insect damage in grand fir cones. U.S.D.A. For. Serv., Intermountain For. and Range Exp. Stn. Res. Note IMT-8. 3 pp.

Cones collected during 1961, a good seed year in northern Idaho, indicated that about 15% of the seed crop was lost to insects. Fir seed maggots, *Earomyia* spp. were present in about 7% of the cones. The fir seed gall midge, *Dasineura abiesmia*, was found in 24% of the cones and caused an estimated seed loss of 3%.

88. Rauf, A.; Cecich, R.A.; Benjamin, D.M. 1981. Life table evaluation of conelet mortality for jack pine in Wisconsin. Proc. 2nd North Cent. For. Tree Improv. Assoc. Conf. August 4-5, 1981. Lincoln, Nebraska. p. 166-175.

Jack pine, *Pinus banksiana* Lamb., cone production was reduced 1.6% by *Resseliella silvana* and *Asynapta hopkinsi*.

89. Reid, R.W. 1956. Coniferous seed and cone insects found in Alberta and Rocky Mountain National Park. Can. Dep. Agric., For. Biol. Div., Bi-Mon. Prog. Rep. 12:3.

Notes the presence of *Earomyia* sp. nr. *nigrociliata* on white spruce and Douglas-fir, *Earomyia* sp. on alpine fir and Douglas-fir, and *Lasiomma (=Pegohylemyia)* sp. nr. *anthracina* on eastern larch. Insect specimens were identified by the systematics unit in Ottawa.

90. Ross, D.A. 1958. A list of cone and seed insects of interior British Columbia. Proc. Entomol. Soc. B.C. 55:30-31.

Insects reared from cones collected during the period 1950-1955 in the interior of B.C. are listed. *Earomyia* spp. were found in the cones of Engelmann and white spruce, western hemlock, Douglas-fir and alpine fir.

91. Rudinsky, J.A. 1955. Douglas fir cone and seed insects (progress report). Weyerhaeuser For. Res. Note 13. 6 pp.

The progress made in the long-term study initiated in 1954 on the cone and seed insects of Douglas fir is reported. Gall midges were common, but are not considered of real economic importance because seed was actually destroyed in only a few instances. A preliminary spray operation with DDT was undertaken and appeared

to be effective in controlling insects. The author suggests that before an adequate test of insecticides can be performed, the life cycles of the cone and seed insects have to be known.

92. Ruth, D.S. 1980. A guide to insect pests in Douglas fir seed orchards. Can. For. Serv., Pac. For. Res. Cent. Inf. Rep. BC-X-204. 19 pp.

A well-illustrated guide to the recognition, biology, and damage of 15 insects that feed on cones and seeds or destroy cone bearing branches of Douglas-fir. A small section on insect control is included. The pest manager should find the chart of feeding periods for the insects (listed in order of importance) very useful. The three species of Diptera listed with their rank of importance are *Contarinia oregonensis* (2), *C. washingtonensis* (7), and *Earomyia barbara* (14).

93. Ruth, D.S.;, Miller, G.E.; Sutherland, J.R. 1982. A guide to common insect pests and diseases in spruce seed orchards in British Columbia. Can. For. Serv., Pac. For. Res. Cent. Inf. Rep. BC-X-231. 28 p.

Another well-illustrated guide that provides succinct descriptions of the life history and damage of *Lasiomma (=Hylema) anthracina, Mayetiola corpophaga, Dasineura rachiphaga, Dasineura canadensis,* and *Resseliella* sp. A chart of insect feeding periods and key is presented.

94. Ruth, D.S.; Senecal, M.A.; Carlson, J.A. 1980. Cone and seed pests, 1980. Can. For. Serv., Pac. For. Res. Cent. Pest Rep. Nov. 3, 1980. 16 pp.

Cone crops of Douglas-fir, lodgepole pine, western hemlock, western larch, western red cedar, Engelmann spruce, ponderosa pine, white spruce, subalpine pine, and whitebark pine were evaluated in numerous localities in the Vancouver, Kamloops, Cariboo and Prince Rupert Forest regions of British Columbia. Individual damage estimates for each insect species are not provided; however it is noted that *Contarinia oregonensis* and *Lasiomma (=Hylemyea) anthracina* were among the most damaging insects of Douglas-fir and spruce, respectively.

95. Schmid, J.M.; Mitchell, J.C.; Stevens, R.E. 1981. *Cydia youngana* (Kearfott) (Lepidoptera: Tortricidae) and associates in Engelmann spruce cone, Fraser Experimental Forest, Colorado 1974-1977. U.S.D.A. For. Serv., Rocky Mt. For. Range Exp. Stn., Res. Note RM-394. 5 pp.

A total of 22 species of insects were found associated with Engelmann spruce cones. Unidentified larvae, possibly *Lasiomma (=Hylemyia)* sp., were found in 15% of the cones examined and accounted for 41% of the seed destroyed in 1976. This species was not present in cones from 1974, 1975 or 1977.

96. Scurlock, J.H.; Mitchell, R.G.; Ching, K.K. 1982. Insects and other factors affecting noble fir seed production at two sites in Oregon. Northwest Sci. 56:101-107.

Dissections of noble fir, *Abies procera* Rehd. cones indicated a 36% seed loss due to insects. Two cone maggots, *Earomyia barbara* and *E. longistyla* and a seed chalcid, *Megastigmus pinus* Parfilt, were associated with about 94% of the insect damage (damage estimates by insect species were not separated). Feeding by both species of lonchaeids left darkened empty seed coats with round, frass-free holes. Cone maggot predation on seed chaleids and gall midges was observed. A *Dasineura* sp. infested about 7% of the seeds. An unidentified resin midge, probably of the genus *Resseliella*, was encountered frequently, but damage (if any) was insignificant.

97. Stone, A.; Sabrosky, C.W.; Wirth, W.W.; Foote, R.H.; Coulson, J.R. 1965. A catalog of the Diptera of America north of Mexico. U.S.D.A., Agric. Handb. 276. 1696 pp.

This catalogue recognizes 1,971 valid genera and 16,130 valid species of Diptera distributed among 105 families. Provides a list of all published names with a reference to the original publication, distinguishes between valid and synonymous names, and gives an indication of the distribution of the species. (Species attacking cones and seeds mentioned in this catalogue are listed in the taxonomic index of this bibliography). A comprehensive bibliography is given at the end of the catalogue.

98. Syme, P.D. 1981. Black spruce cone and seed insects - a special study. Can. For. Serv., Great Lakes For. Res. Cent., Forestry Res. Newsletter, Summer 1981. p. 1-2.

In 1980, three regions in northern Ontario were sampled to determine insect populations on male and female flowers/cones of black spruce, *Picea mariana* (Mill.) B.S.P. Cone damage by *Lasiomma (=Hylemyia) anthracina* was up to 17, 19 and 18% for the northwestern, north central and northern regions respectively. The spruce cone axis midge, *Dasineura rachiphaga*, was reponsible for up to 23, 25 and 5% cone damage in the northwestern, north central and northern regions, respectively.

99. Teskey, H.J. 1976. Diptera larvae associated with trees in North America. Mem. Entomol. Soc. Can. 100. 53 pp.

Provides an identification key and illustrations of larvae for 43 families of North American Diptera associated with living and dead trees. Very useful descriptions of the important identification characteristics of the families are given (larvae of the Diptera are extremely variable in form). A short summary of the importance of the family Cecidomyiidae and its general life cycle is given.

100. Timonin, M.I.; Fogal, W.H.; Lopushanski, S.M. 1980. Possibility of using white and green muscardine fungi for control of cone and seed insect pests. Can. Entomol. 112:849-854.

Preconditioned isolates of *Beauveria bassiana* and *Metarrhizium anisopliae* were tested in the laboratory against larvae and puparia of *Dasineura rachiphaga*, *D. canadensis*, and *Lasiomma anthracina*. Both fungi were highly virulent towards larvae of the two *Dasineura* spp., with 100% mortality being obtained less than 48 h after inoculation. Larvae of *L. anthracina* were more resistant to both fungi: 100% mortality was finally obtained five days after inoculation. Puparia of all three species required longer incubation (5-6 days) to obtain 100% mortality.

101. Tripp, H.A. 1954. The instars of a maggot (Pegohylemyia) inhibiting white spruce cones. Can. Entomol. 86:185-189.

Describes and illustrates the three larval instars of *Lasiomma (=Pegohylemyia) anthracina*. The first instar larva develops within the egg chorion leaving only two free-living instars. The presence of a somewhat suppressed first-instar buccopharyngeal skeleton within the egg and first-instar excuviae clearly indicate a moult before hatching. A short outline of the life cycle is given.

102. Tripp, H.A. 1955. Descriptions and habits of a Cecidomyiidae (Diptera) from white spruce cones. Can. Entomol. 87:253-263.

Provides a comprehensive literature review of the gall midges attacking white spruce. Descriptions of all stages of *Dasineura canadensis* and observations on the seasonal life history and habits are presented. Two new species, *Dasineura rachiphaga* and *Phytophaga (=Mayetiola) carpophaga* are described with notes on their seasonal life history. Illustrations of characteristic features of the species described are given. Descriptions, notes, and a key of two unidentified cecidomyiid larvae are included.

103. Tripp, H.A.; Hedlin, A.F. 1956. An ecological study and damage appraisal of white spruce cone insects. For. Chron. 32:400-410.

This important early work brings together the biology and bionomics of several important insects feeding on white spruce cones, and discusses their roles and relationships within the habitat of the cone. Descriptions of the habits of *Lasiomma (=Pegohylemyia) anthracina, Dasineura canadensis, D. rachiphaga, Mayetiola (=Phytophaga) carpophaga,* and two species of cecidomyiids named 'A' and 'B' are provided. By dissection of cones, it was calculated that an individual maggot of *P. anthracina* would destroy anywhere from 30 to more than 90% of the seed in the productive zone of the cone. Average seed destruction was about 60%, which amounts to 25% of the potentially sound seed. Of the cecidomyiids, only *P. - carpophaga* and species 'A' actually destroyed the seeds of white spruce. When cones were abundant, both species combined infested about 3% of the cones, for an estimated total seed loss of 0.05%. The seed destroying capacity of the cecidomyiids was heavily masked by the feeding habits of *Cydia (=Laspeyresia) youngana* and *P. anthracina,* particularly when cones were scarce. The feeding habits of the latter two species may keep the seed cecidomyiids at endemic levels because it was noted that galled seeds were eaten by these insects. It is suggested that should *L. youngana* and *P. anthracina* be eliminated, it could be possible that the seed cecidomyiids would become serious seed destroyers. *D. canadensis* enjoyed an existence relatively free from competing insects. If *L. youngana* was present in the cone *D. rachiphaga* would not survive.

104. Werner, R.A. 1964. White spruce seed loss caused by insects in interior Alaska. Can. Entomol. 96:1462-1464.

From 1958 to 1962, white spruce cones were collectd and examined to determine the insects species present and the associated damage to the scales, rachis and seeds. Diptera larvae noted were *Dasineura canadensis, D. rachiphaga,* and *Mayetiola (=Phytophaga) carpophaga,* and a *Lasiomma (=Pegohylemyia)* sp. The latter insect was recorded for the first time in Alaska and the damage caused by this pest is similar to that of the spruce cone maggot *Lasiomma (=Pegohylemia) anthracina.*

105. Williams, I.L.; Fatzinger, C.W. 1977. A new cone midge, Cecidomyia spp. (Diptera: Cecidomyiidae) affecting slash pine cones. pp. 104-107 *in* Proc. Fourteenth South. For. Tree Improv. Conf., Gainsville, Fla., 1977.

Cone midge larvae, tentatively identified as *Cecidomyia* spp., possibly *resincola,* (subsequently identified as *Cecidomyia biseta* - see ref 22, editor) caused hypertrophied scales in *Pinus elliotlii* Engel. var. *elliotlii.* Larvae were observed feeding on seed wing tissue and interior surfaces of the scales but not on ovules. Feeding by the midge was found to cause cone mortality.

106. Yates, H.O. III. 1973. Light trapping in seed orchards under a pest management system. Proc. 12th South. For. Tree Improv. Conf. p. 91-96.

Notes that cone midges of the family Cecidomyiidae are not readily captured by light traps.

107. Yates, H.O., III; Ebel, B.H. 1978. Impact of insect damage on loblolly pine seed production. J. Econ. Entomol. 71:345-349.

Cecidomyiidae larvae were responsible for the death of 21 loblolly, *Pinus taeda* L., cones (6.9%) in 1969 and 24 cones (8%) in 1970. Peak losses during both years were during June and July with a secondary peak in early October. Only one conelet was killed by the midges within the 2 year study period.

108. Yearian, W.C.; Warren, L.O. 1964. Insects of pine cones in Arkansas. J. Kans. Entomol. Soc. 37:259-264.

Insects were reared and collected from cones and conelets of loblolly pine and shortleaf pine. One specimen of *Oscinella (=Haplaginella) conicola* (Greene) was reared during the study. (Unfortunately the host species was not noted).

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